Remarks

Extension of Time

Accompanying this response is a Petition to Extent Time for Response by one (1) month from December 11, 2003 to January 11, 2004.

Amendments to the Claims

Claims 1-25 remain in the application for reconsideration.

Method claim 6 and apparatus claim 19 have been amended to correct an inadvertent error in designating the backside, rather than the frontside, emission as being detected by the array of photodetection circuits. Accordingly, these claims have been conformed, for example, to the illustrative embodiment of FIG. 2 and its corresponding description at page 5 *et seq.* of the specification.

No new matter has been added by these amendments.

Amendments to the Specification

Please amend the specification at page 5, line 14, to delete the word ***a*** after the word ***measuring*** as follows:

> In accordance with another embodiment of our invention, the foregoing testing method may be applied to VCSELs one at a time; that is, single, discrete VCSELs or single VCSELs in an array. One-at-a-time testing may be done in well-known step-and-repeat fashion. Thus, at an intermediate stage of its manufacture, a bottom-emitting VCSEL is tested by measuring [[a]] the backside emission that leaks through the backside reflector, determining whether a selected quality of the VCSEL meets predetermined specification, and then finishing the VCSEL assembly in a configuration that is designed to use radiation emitted from the frontside reflector. In final assembly the substrate is typically removed.

The foregoing amendment to page 5 is purely grammatical and serves to improve the clarity of the description.

Please amend the specification at page 6, line3, to delete the number ***12*** and insert the number ***122***, as follows:

> In accordance with another aspect of our invention, FIG. 2 shows apparatus 100 for testing an array 112 of bottom-emitting VCSELs 115 formed on a transparent substrate 114. As before, the array 112 is depicted at an intermediate stage of its manufacture. In this case, however, the drive circuitry 118 and the photodetection circuitry 120 are separated from one another. The electronic array 116, which includes the drive circuitry 118, is aligned with the top surface of the VCSEL array and is electrically coupled thereto via contacts 130 and 140 on the VCSEL and electronic arrays, respectively. The photodetection array ~~12~~ 122, which includes photodetectors 120 (and associated detection circuits, not shown), is aligned with the VCSEL array 112 so that a particular photodetector (e.g., 120a) is nominally positioned to receive only the primary, frontside emission (e.g., 121a) of its corresponding VCSEL (e.g., 115a). However, because the VCSELs are relatively densely packed, because their output beams tend to diverge (especially over the relatively large thickness of the substrate 114), and further because the photodetectors tend to have relatively broad photosensitive areas, each photodetector (e.g., 120a) may receive unwanted, stray optical radiation (e.g., 121b and 121c) from adjacent or other non-adjacent VCSELs. This stray radiation or cross-talk will, of course, distort the data received by the photodetector in question (e.g., 120a), thereby providing a false measurement of the performance of the VCSEL (e.g., 115a) associated with that photodetector.

The foregoing amendment to page 6 conforms the description to the formal drawing and serves to improve the clarity of the description.

No new matter has been added in either of these amendments.

Summary of the Invention

Before discussing the rejection on the merits, it will be helpful to briefly review Applicants' invention. In accordance with one aspect of the invention, in a method of testing an optoelectronic device that includes a VCSEL, an optical signal ***leaking through a higher reflectivity backside reflector*** is measured and compared to a predetermined quality specification

(method claim 1, lines 4-7) and then the device is finished in a configuration that uses radiation ***emitted from a lower reflectivity frontside reflector*** (claim 1, lines 8-9). Corresponding features are found in apparatus claim 15.

In accordance with another aspect of the invention, an array of ***bottom-emitting VCSELs*** (method claim 3, line 1), with its substrate still intact, is tested by means of a probe that includes an optoelectronic array, which is aligned and coupled to the top surface of the VCSEL array. The probe is aligned to the VCSEL array just once. The optoelectronic array includes driver circuits for energizing the VCSELs and the photodetection circuits in a predetermined sequence for ***detecting the back emission that leaks through the top mirror of each VCSEL*** (claim 3, lines 7-8). The detected radiation is measured and compared to a predetermined quality specification (method claim 3, lines 9-11) and then the device is finished in a configuration that uses radiation ***emitted from a lower reflectivity frontside reflector*** (claim 3, lines 12-13). Corresponding features are found in apparatus claim 17. In another embodiment, this probe and method are applied to testing bottom-emitting VCSELs one at a time. The VCSELs may be discrete devices or part of an array.

In accordance with yet another aspect of our invention, an array of ***bottom-emitting VCSELs*** (method claim 6, line 1), with its substrate still in intact, is tested by means of a probe that includes ***separate electronic and photodetection arrays*** (claim 6, lines 5-9). The probe is aligned to the VCSEL array just once; that is, ***without performing another act of aligning said probe*** (claim 6, line 10). The electronic array, which is electrically coupled, for example, to the ***top surface*** of the VCSEL array (claim 6, line 6), includes driver circuits for energizing the VCSELs. The photodetection array is aligned and coupled, for example, to the ***bottom*** of the substrate (claim 6, line 8) in order to ***detect the primary bottom emission of the energized VCSELs*** (claim 6, lines 8-9). The photodetection array is aligned so that each detector receives the emission from a particular VCSEL, but because the substrate is relatively thick, the divergence of the bottom emission produces cross-talk; that is, the bottom emission of one VCSEL may be received by an adjacent photodetector that is supposed to detect only the emission from another VCSEL. To alleviate this cross-talk problem, ***the VCSELs are energized in a first predetermined sequence and/or the photodetector circuitry is turned on in a second***

predetermined sequence (claim 6, lines 12-13). Corresponding features are found in apparatus claim 19.

Both aspects of our invention enable testing of an entire array essentially simultaneously, thereby reducing costs of testing to the point that it is feasible to test all VCSEL arrays prior to final assembly. Since only VCSEL arrays that meet specification are assembled, final device yields are improved. Furthermore, and in accordance with another embodiment of our invention, the drive circuits to the VCSELs that do not meet specification are turned off in the final device, thereby reducing power consumption wasted on such VCSELs.

Claim Rejections – 35 USC 103

Claims 1-25 have been rejected under 35 USC 103(a) as being unpatentable over J. W. Scott, US Patent No. 6,160,834 (hereinafter ***Scott***). The Examiner states his position as follows:

> The Scott reference shows testing, in an intermediate step, vertical cavity surface emitting lasers, and using the results to make decisions as to further processing. The test, shown in figure 5 of that reference, comprises aligning a probe with the laser being tested, energizing the laser, measuring its output, and determining form [*sic*] its measured output what further processing maybe [*sic*] required; see column 5, lines 10-21. Although Scott et al shows a single probe (54) and a single detector (56) to test a single laser at a time, although [*sic*] the reference teaches that a plurality of lasers be tested (column 5, lines 45-46, 49-50). It would have been obvious to provide a plurality of probes and detectors to test a plurality of lasers at the same time to speed up the process. The mere duplication of parts required for this is a simple and straightforward modification of the instrument shown by the reference, with each test operating in the same manner as the one shown.

This rejection is respectfully traversed for the reasons set forth below.

(1) **Single v. Multiple Probes:** The Examiner's argument focuses on the assumption that Applicant's invention is limited to the use of ***a plurality of probes***, which is true only for claims 3-14 and 17-25. In contrast, claims 1-2 and 15-16 embrace the use of either a ***single probe*** or a ***plurality of probes***. Where a plurality of probes is used, they are configured in an array so that a multiplicity of VCSELs may be tested simultaneously. In this regard, the Examiner points to column 5, lines 45-50 of Scott

as teaching ***that a plurality of lasers be tested***, but this section of Scott relates only to sampling a plurality of VCSELs in step-and-repeat fashion and does not suggest that a multiplicity of VCSELs is tested simultaneously. Moreover, the Examiner's opinion omits any reference to other significant features of Applicants' claims, which are neither taught nor reasonably suggested by Scott, as discussed *infra*.

(2) **Top-Emitter v. Bottom-Emitter:** Scott describes only a top-emitter; that is, the primary emission emerges from the lower reflectivity upper mirror 18 through the aperture in the p-contact 32. Scott's testing procedure measures this topside primary emission to determine the slope efficiency of his VCSELs and the thickness of the variable thickness dielectric tuning layer 10 to be deposited. No significant backside emission would emerge from the higher reflectivity lower mirror 14 because any radiation leaking through that mirror would be absorbed by the metallic n-contact 30 located on the bottom of substrate. In addition, Scott makes no mention of utilizing such backside emission in his testing procedure. In contrast, Applicants' method claim 1, lines 4-5 and apparatus claim 15, lines 5-6, both require that the measurement of an optical signal ***leaking through said backside reflector***. Similar limitations are found in method claim 3, lines 7-8 and apparatus claim 17, lines 6-7. Moreover, method claims 3-14 and apparatus claims 17-25 all explicitly require that the VCSEL be a ***bottom-emitting VCSEL***. (See, line 1 of independent claims 3, 6, 17 and 19.)

(3) **Aligning the Probe Just Once:** Scott teaches a step-and-repeat approach to testing his VCSELs, in which that the autoprober 54 of FIG. 5 must be realigned with each VCSEL after each step in a sequential process. In contrast, one aspect of Applicants' invention entails a parallel process in which the probe is aligned ***just once*** with the VCSELs, and radiation leaking from backside reflectors of a multiplicity of VCSELs is measured ***without performing another act of aligning said probe*** (claim 2, lines 1-3; claim 3, line 9; claim 16, lines 1-3; claim 17, line 8; claim 19, line 10). Similar features are present in the embodiments of Applicants' invention used to measure primary frontside emission (claim 6, line 10).

(4) **Activation and Photodetection Arrays on Opposite Sides:** In one embodiment of Applicants' invention a first array of electronic circuits is coupled to one side of the VCSEL array and a second array of photodetectors is coupled to an ***opposite side*** of the VCSEL array (claim 6, lines 5-9; claim 19, lines 5-9). This feature addresses the detection of primary emission propagating ***through the substrate*** and is not even remotely suggested by Scott, which, in contrast shows at single autoprober 54 and a single photodetector 56 both located on the ***same side*** of his VCSEL array for detecting primary emission emerging ***through top mirror 18***, not through substrate 12.

(5) **Cross Talk:** An important feature of another embodiment of Applicants' invention addresses the problem of cross talk, which arises when the primary emission propagating through the substrate diverges so much that radiation is detected not only by the intended photodetector in an array of such detectors but also by one or more unintended photodetectors adjacent thereto. Applicants' solution to this problem includes energizing and/or turning off selected circuits of the drive electronics array and/or the photodetector array in a predetermined sequence that reduces cross talk. See, claim 6, lines 12-13; claims 7-11; claim 19, lines 12-14; and claims 20-25. Scott fails to recognize this problem and furthermore is totally devoid of any teaching or reasonable suggestion of Applicants' solution to it, as set forth in claims 6-11 and in claims 19-25.

Conclusion

In view of the foregoing, reconsideration of claims 1-25, and passage of this application to issue, are hereby respectfully requested. If during the consideration of this paper, the Commissioner believes that resolution of the issues raised will be facilitated by further discussion, he is urged to contact the undersigned attorney at 610-691-7710 (voice) or 610-691-8434 (fax).

Respectfully,

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By ______________________
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Date: ______________